U.S. AIR FORCE

HBOT AS ADJUNCT IN NON-HEALING WOUNDS APPROACH & OUTCOMES

Vipin Sharma, AAMIMO

Plan

- Introduction
  - HBOT
  - HBOT in Non-healing ulcers
- Aims & Objectiv
- Material & Meth
- Results & Discus
- Salient features
- Questions

Introduction

- HBOT
  - Breathing 100 % O_2
  - 1.4 ATM ABS or more
- Clinical references' milestones
  - 1930's- divers
  - 1940's US Navy treatment tables
  - 1976 Undersea & Hyperbaric Society established HBOT Committee

Introduction

- Evidence based
  - Physiologic rationale
  - In vivo & in vitro studies
  - Controlled animal studies
  - Prospective controlled clinical studies
  - Clinical experience from hyperbaric medicine centers
- Indications for HBOT
- Utilization review
  - Annual

HBO THERAPY

100% O_2 under pressure in chamber

Increase PP of O_2

Pressure

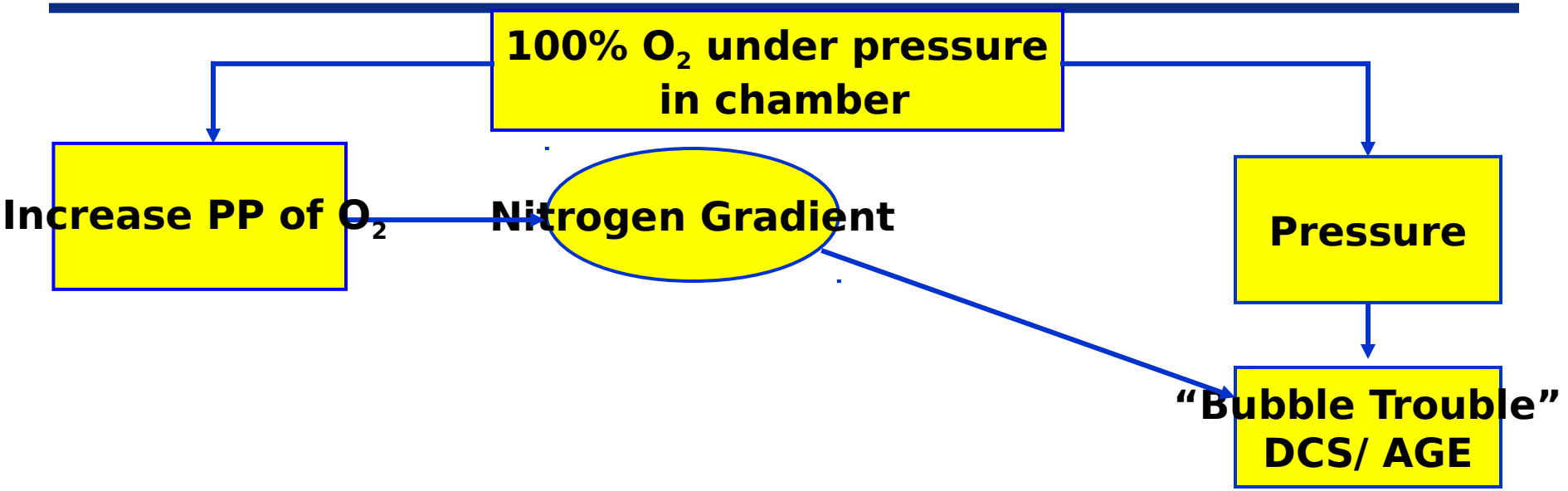
HBO THERAPY

100% O_2 under pressure in chamber

Increase PP of O_2 → **Nitrogen Gradient**

Pressure

HBO THERAPY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"Bubble Trouble"
DCS/ AGE

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Acute Carbon monoxide Poisoning

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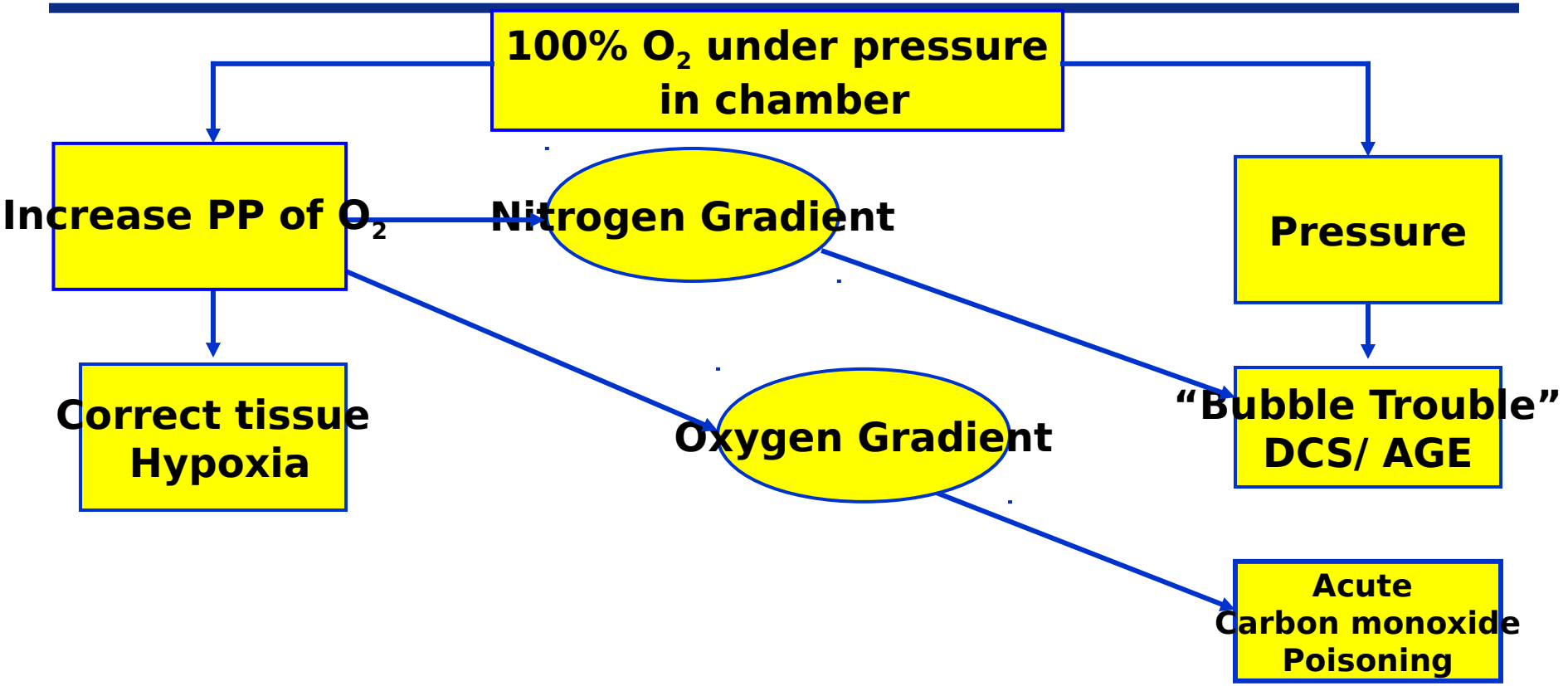
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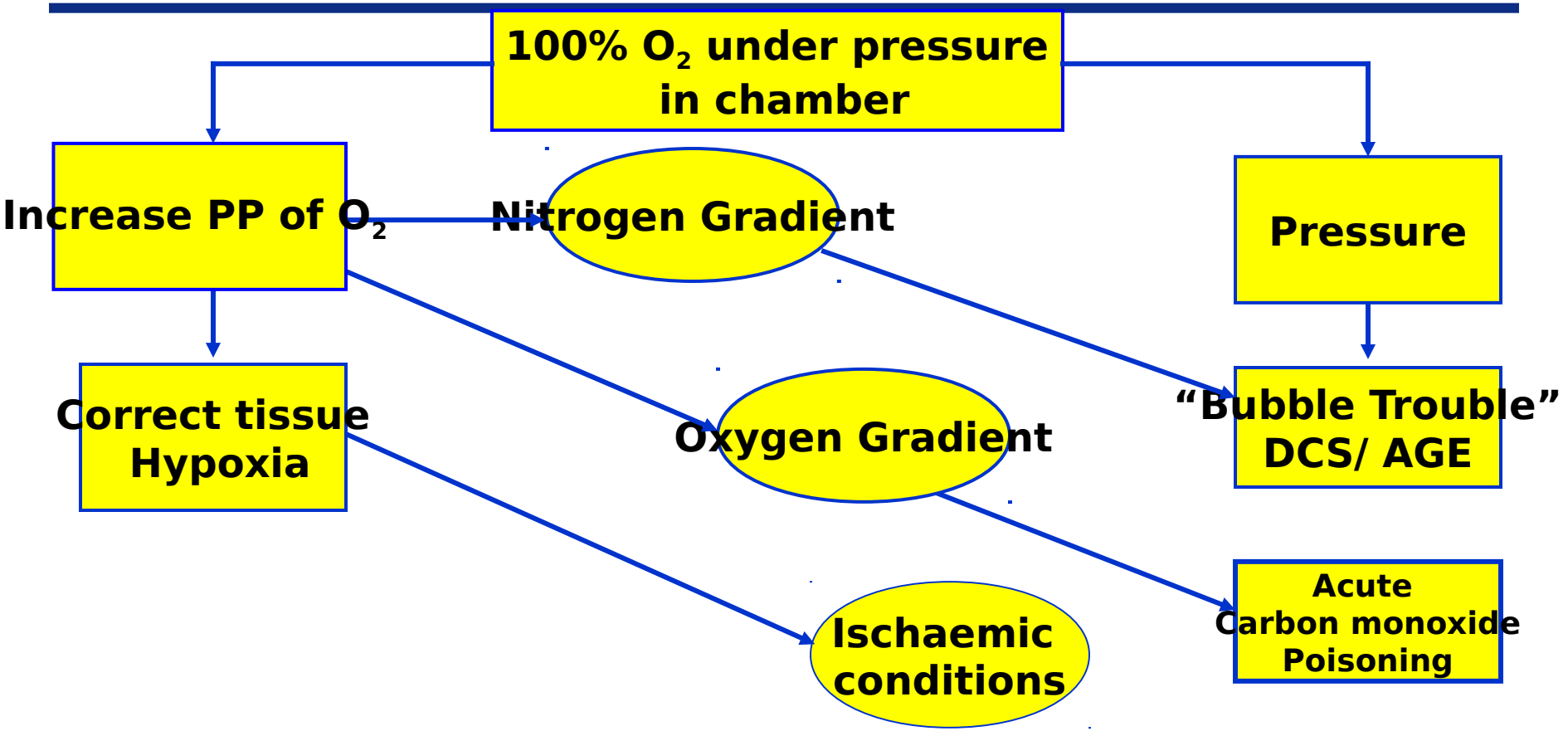
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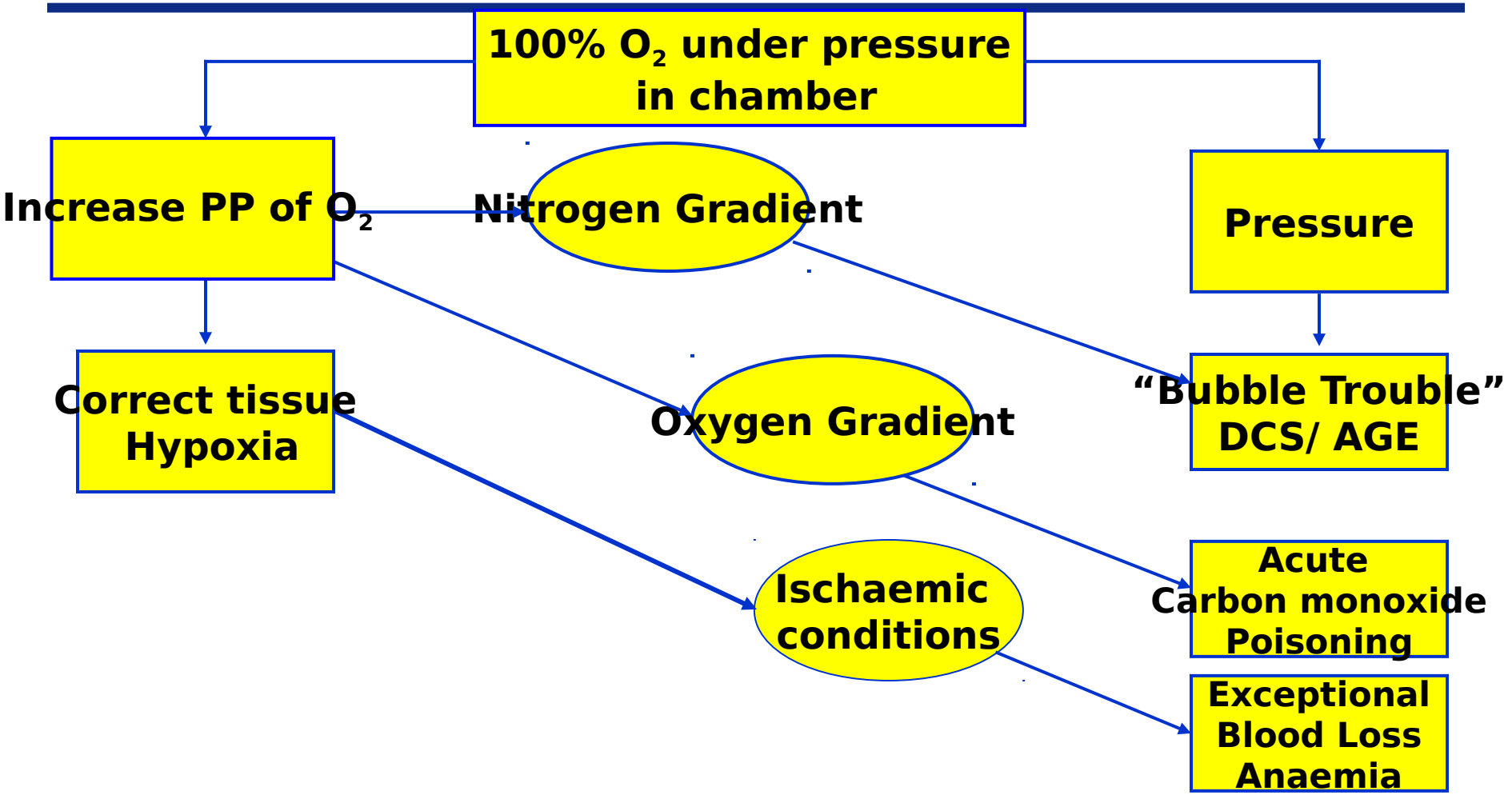
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Acute Carbon monoxide Poisoning
Exceptional Blood Loss Anaemia

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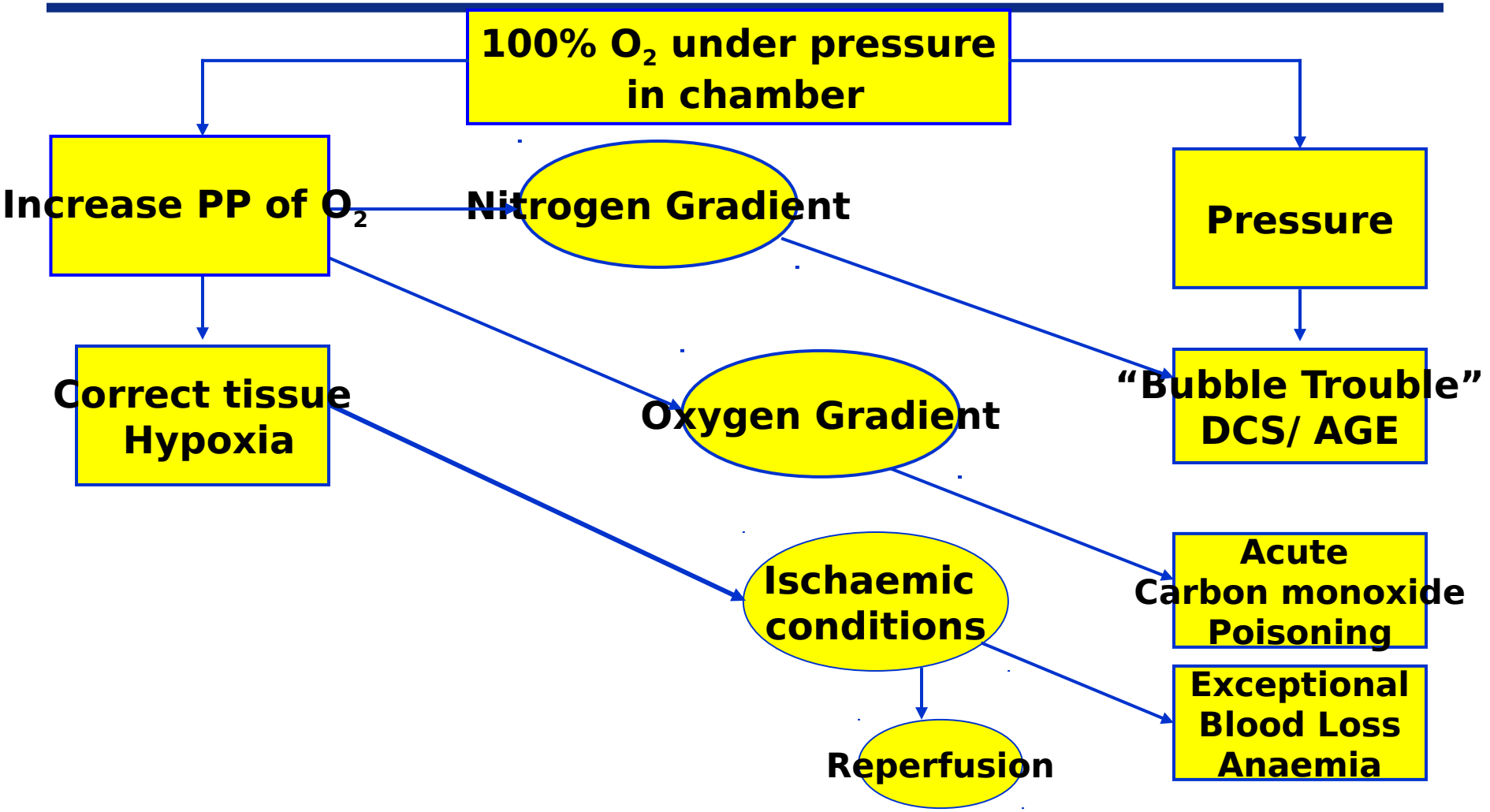
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Reperfusion

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Increase PP of O_2

Nitrogen Gradient

Pressure

Correct tissue Hypoxia

Oxygen Gradient

"Bubble Trouble" DCS/ AGE

Ischaemic conditions

Acute Carbon monoxide Poisoning

Exceptional Blood Loss Anaemia

Reperfusion

Crush Injury/ Compromised Grafts/Flaps

HBO THERAPY

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Increase PP of O_2

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"Bubble Trouble" DCS/ AGE

Infection control

Ischaemic conditions

Acute Carbon monoxide Poisoning

Exceptional Blood Loss Anaemia

Reperfusion

Crush Injury/ Compromised Grafts/Flaps

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Infection control

Ischaemic conditions

Acute Carbon monoxide Poisoning

Clostridial GG ICA Refr OM

Exceptional Blood Loss Anaemia

Reperfusion

Crush Injury/ Compromised Grafts/Flaps

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Infection control

Wound Healing

Ischaemic conditions

Acute Carbon monoxide Poisoning

Clostridial GG ICA Refr OM

Exceptional Blood Loss Anaemia

Reperfusion

Crush Injury/ Compromised Grafts/Flaps

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Infection control

Wound Healing

Ischaemic conditions

Acute Carbon monoxide Poisoning

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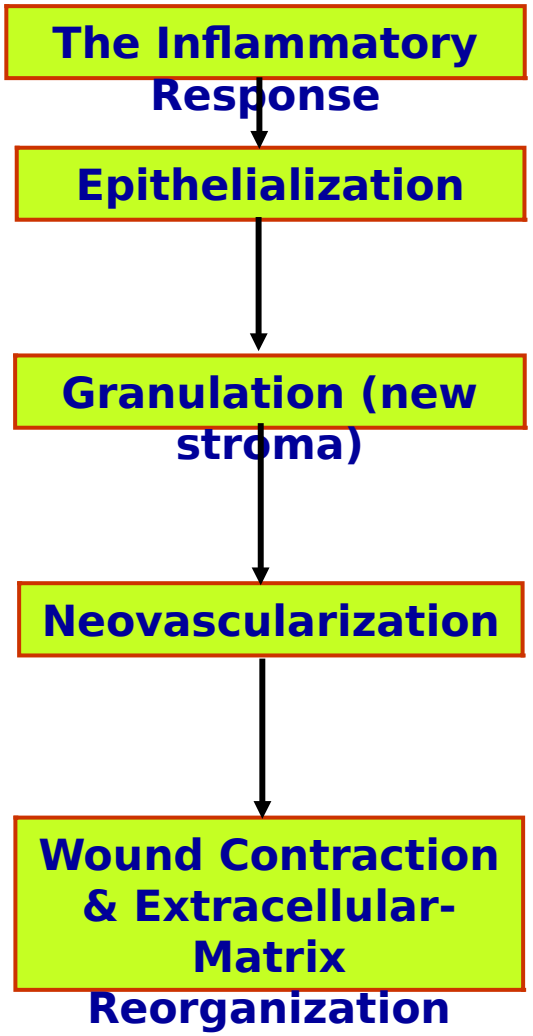
Reperfusion

Exceptional Blood Loss Anaemia

Acute Thermal Burns ORN Diabetic Ulcers Vascular Insufficiency

Crush Injury/ Compromised Grafts/Flaps

Wound Healing



Wound Healing

The Inflammatory Response

Epithelialization

Granulation (new stroma)

Neovascularization

Wound Contraction & Extracellular-Matrix Reorganization

⇒**Tissue Injury**

⇒**Disruption of Blood vessels- extravasation**

⇒**Haemostasis, platelet mediated**

⇒**Complement pathway- Macrophages and fibroblasts**

⇒**Inflammatory leucocytes recruited**

⇒**Chemical mediators - Phagocytosis**

Wound Healing

- **The Inflammatory Response**
- **Epithelialization**
  - ⇒Epidermal cells remove clot/ damaged stroma
  - ⇒Phenotypic alteration
  - ⇒Formation of peripheral cytoplasmic actin
  - ⇒Integrin guided cell migration
  - ⇒Collagenase/ plasmin induced extracellular matrix degeneration
  - ⇒Proliferation of epidermal cells
- **Granulation (new stroma)**
  - ⇒Growth factors aided matrix proliferation
- **Neovascularization**
- **Wound Contraction & Extracellular-Matrix Reorganization**

Wound Healing

The Inflammatory Response

Epithelialization

Granulation (new stroma)

Neovascularization

Wound Contraction & Extracellular-Matrix Reorganization

- ⇒Neocapillarisation
- ⇒Macrophage-source of growth factors
- ⇒Fibroblast- new extracellular matrix
- ⇒Blood vessels- Oxygen & nutrients
- ⇒Active proteolytic system
- ⇒Collagenous matrix formation
- ⇒Apoptosis- acellular scar

Wound Healing

The Inflammatory Response

Epithelialization

Granulation (new stroma)

Neovascularization

⇒Fibroblast growth factor & hypoxia induced

⇒Endothelial cell migration & mitogenic stimulation

⇒Angiogenesis

⇒Apoptosis of extra vessels

Wound Contraction & Extracellular-Matrix Reorganization

Wound Healing

The Inflammatory Response

↓

Epithelialization

↓

Granulation (new stroma)

↓

Neovascularization

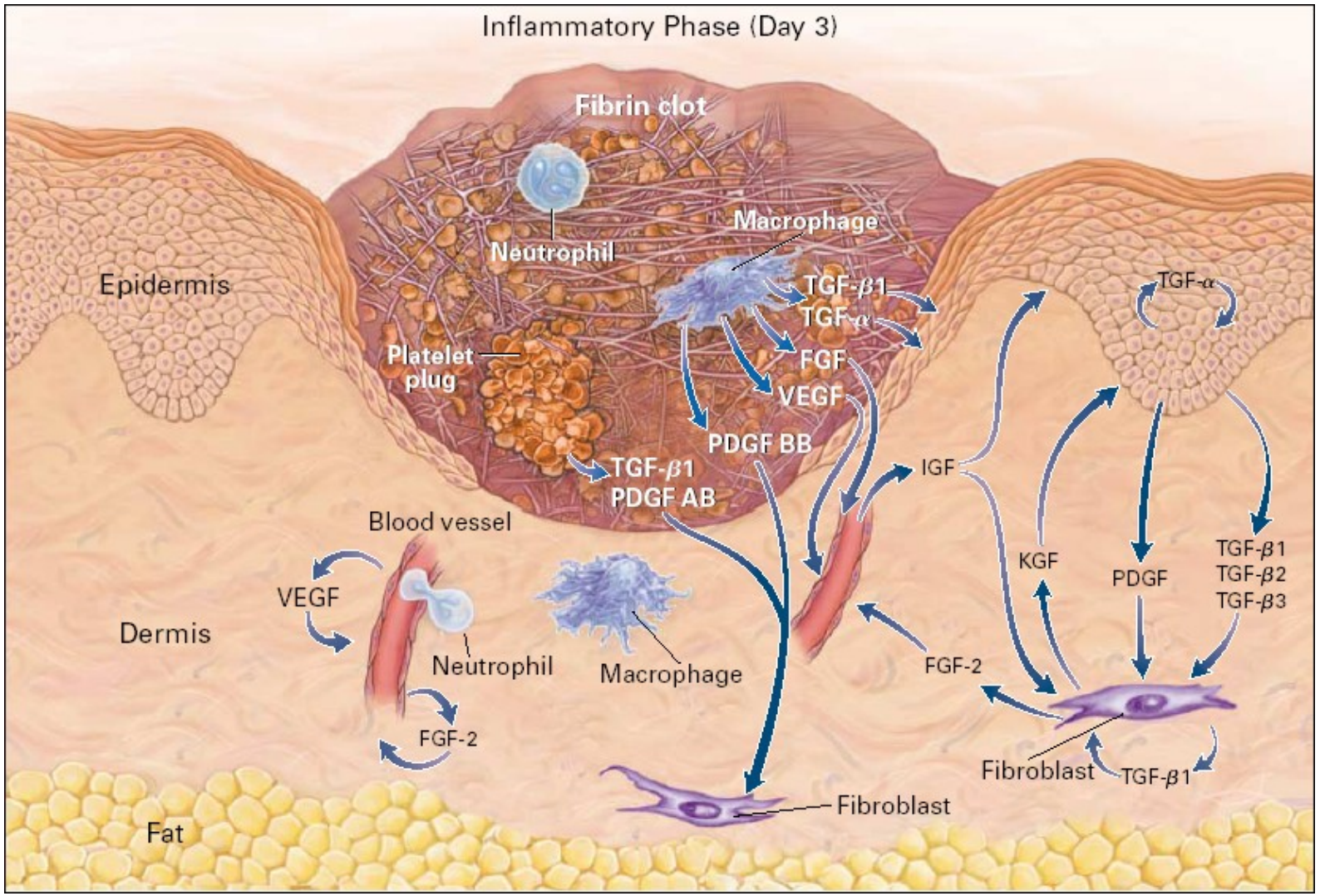
↓

Wound Contraction & Extracellular-Matrix Reorganization

→

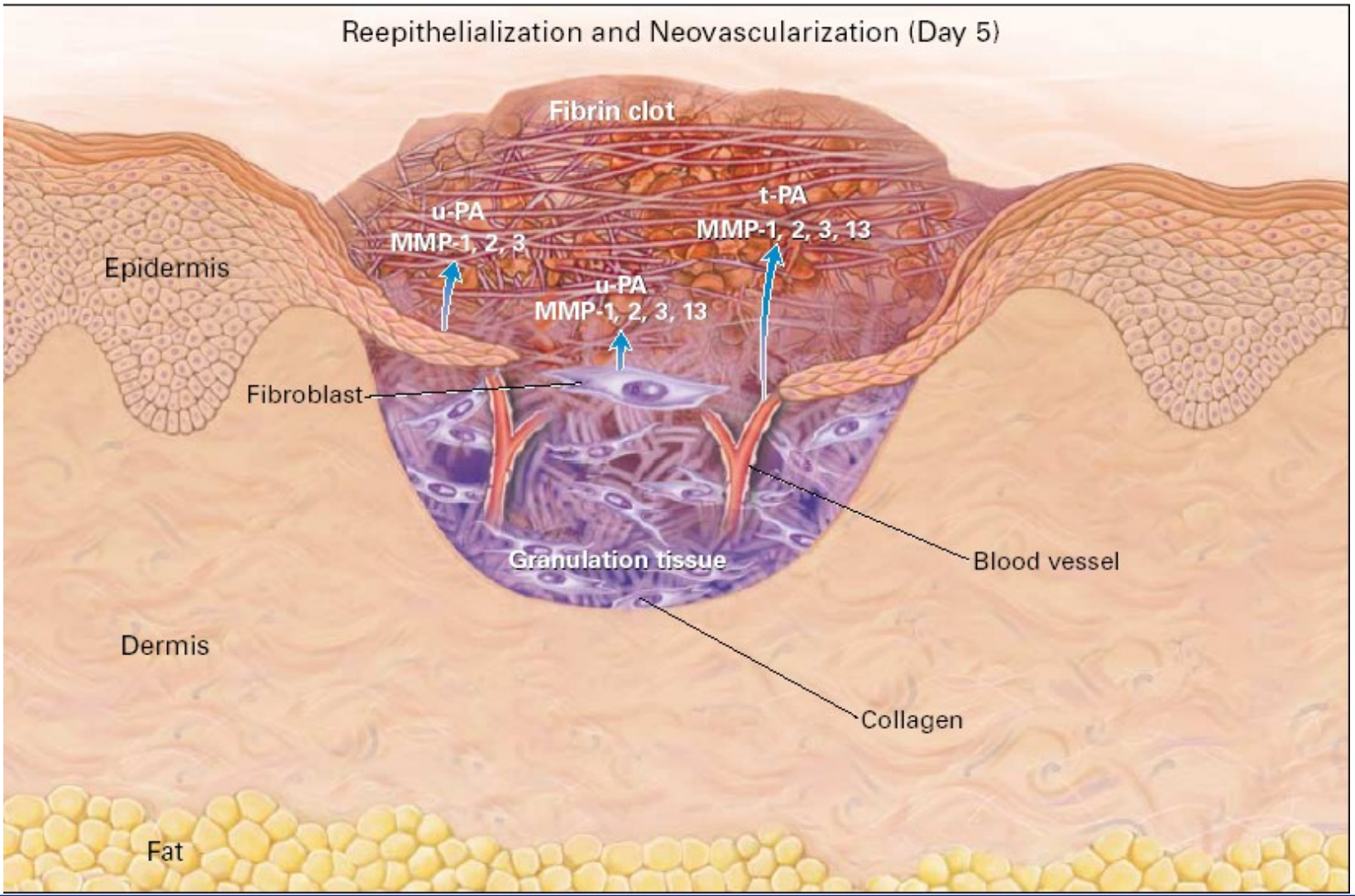
- ⇒Interplay of cells/ extra cellular matrix & cytokines
- ⇒Myofibroblasts
- ⇒Collagen remodeling- matrix metallo-proteinases
- ⇒Collagen binding and reorganization

Wound Healing Day 3



Team Aerospace Begins Here!

Wound Healing Day 5



Team Aerospace Begins Here!

Wound Healing

The Inflammatory Response

↓

Epithelialization

↓

Granulation (new stroma)

↓

Neovascularization

↓

Wound Contraction & Extracellular-Matrix Reorganization

HBOT

Improved outcome

HBO THERAPY IN WOUND HEALING

- Improved leucocyte function and bacterial killing
- Antibiotic potentiation
- Enhanced collagen synthesis and cross linking
- Vasoconstriction with preservation of oxygenation
- Direct antimicrobial effects, toxin synthesis suppression
- Blunting of systemic anti-inflammatory responses
- Prevention of leucocyte activation and adhesion
- PDGF-BB receptor stimulation
- VEGF release and angiogenesis
- Decreased intracellular adhesion molecule (ICAM-1) protein expression

Aims & Objectives

- **Aims**
  - To study the approach to non-healing wounds at Davis Hyperbaric Laboratory
  - To study the outcome of HBOT in non-healing wounds
- **Objectives**
  - To develop a advanced wound care paradigm for intended use at Institute of Aerospace Medicine, India

Material & Methods

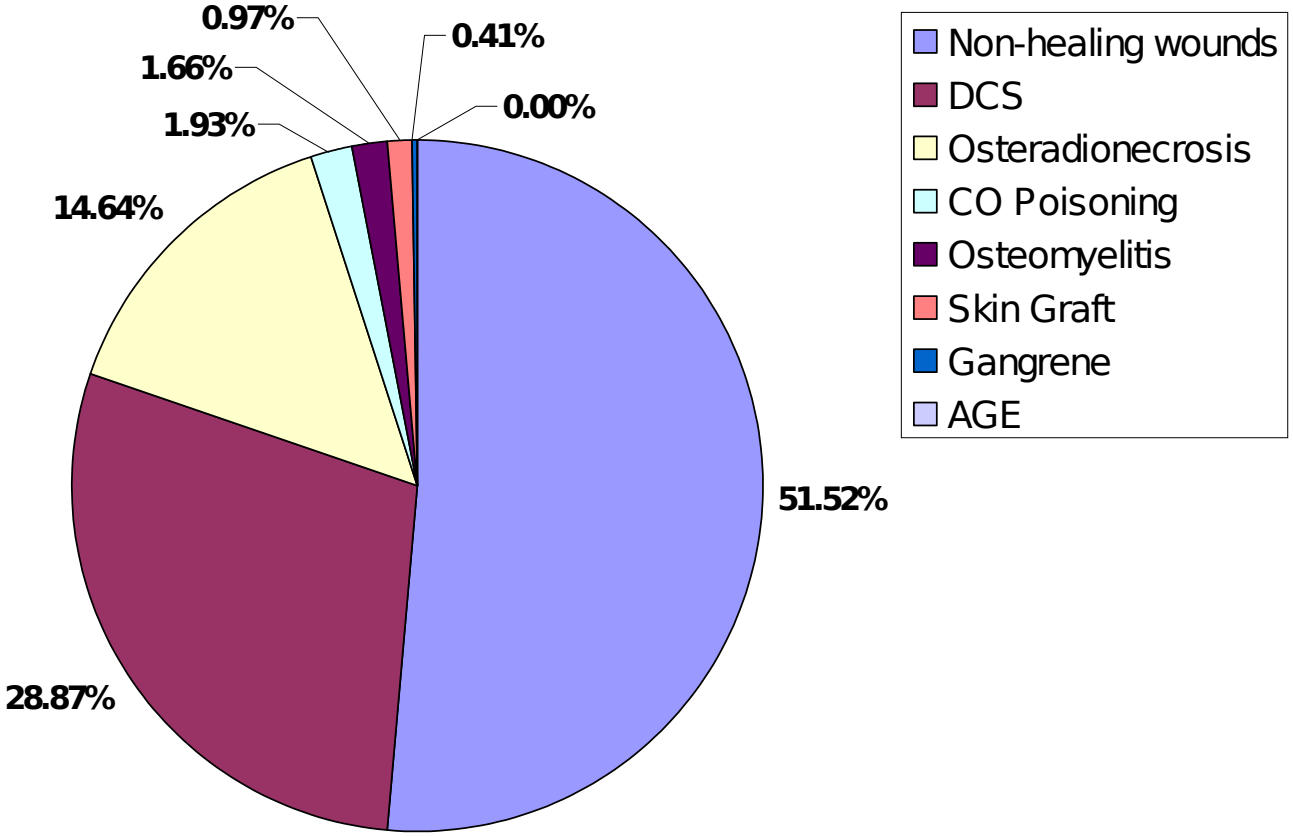
- Study data at Davis Hyperbaric Laboratory
  - Old reported series
  - 5 year data
- Wound Care at Davis Hyperbaric Laboratory
  - Wound assessment
  - Wound care
  - HBOT application
  - Reassessment

In God we trust....

The rest must present data.

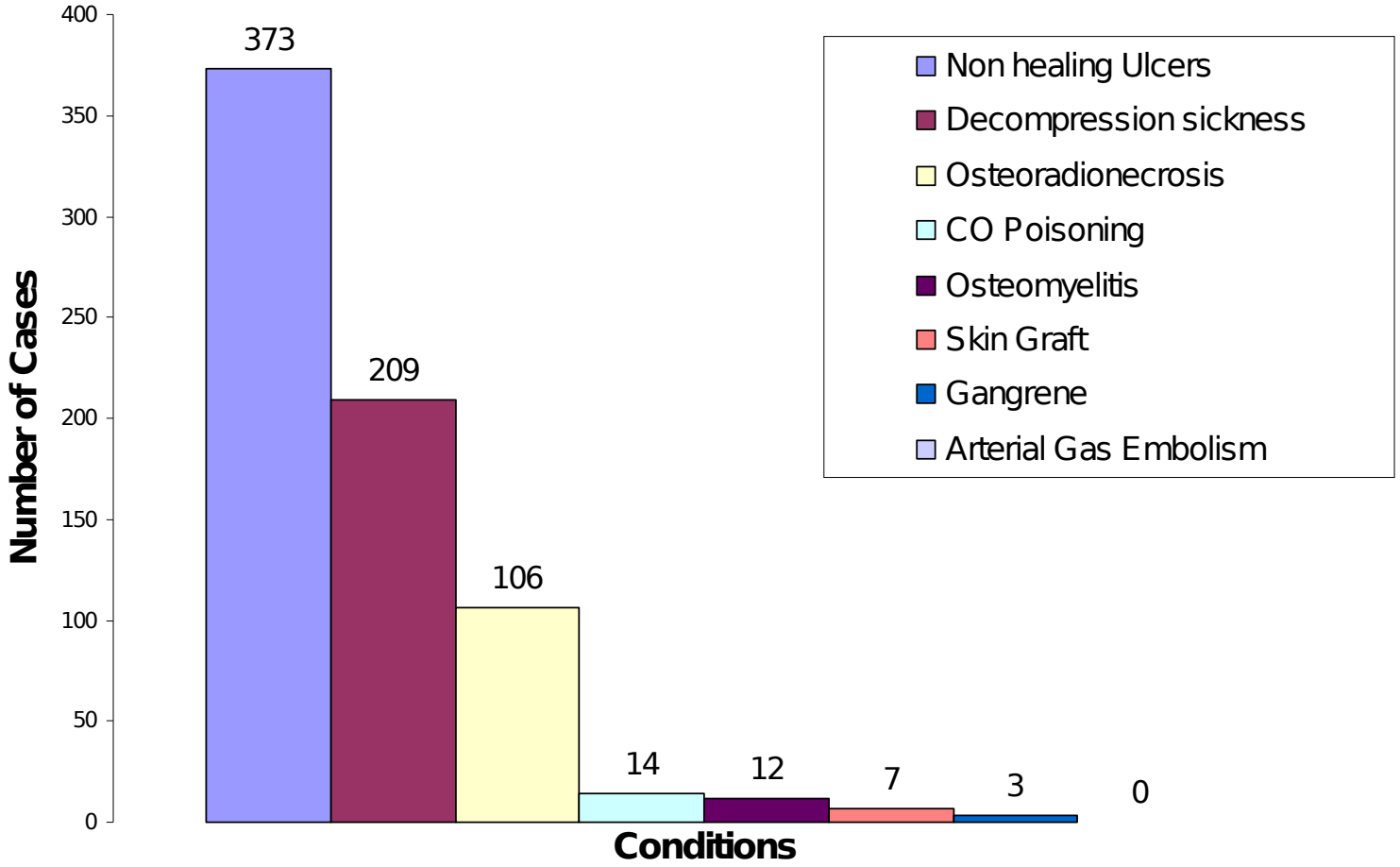
Results

Breakup of cases managed with HBOT between 1997- Mar 2003 (n=724)



Results

Condition wise distribution of cases treated with HBOT 1997- Mar 2003 (n=724)



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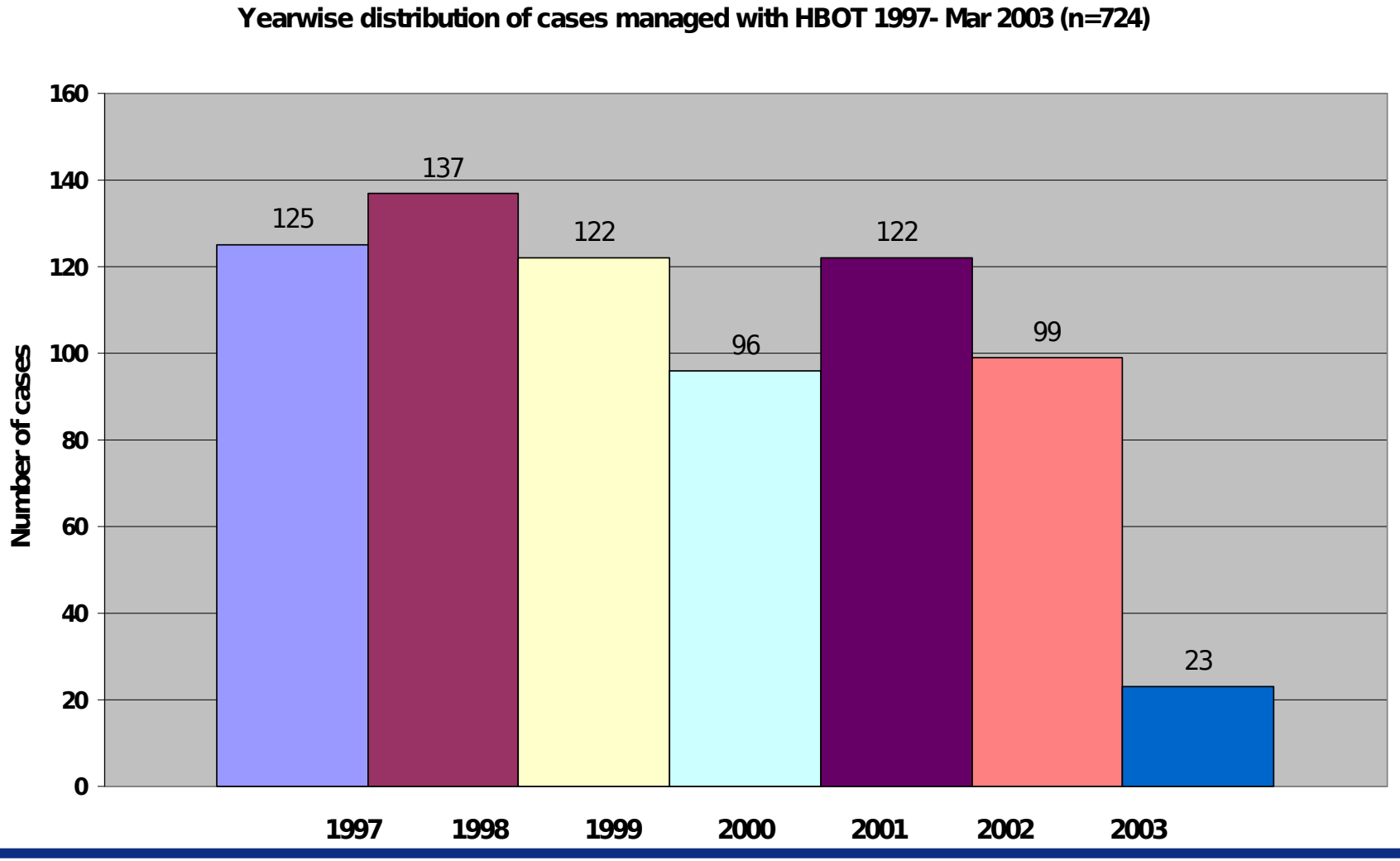
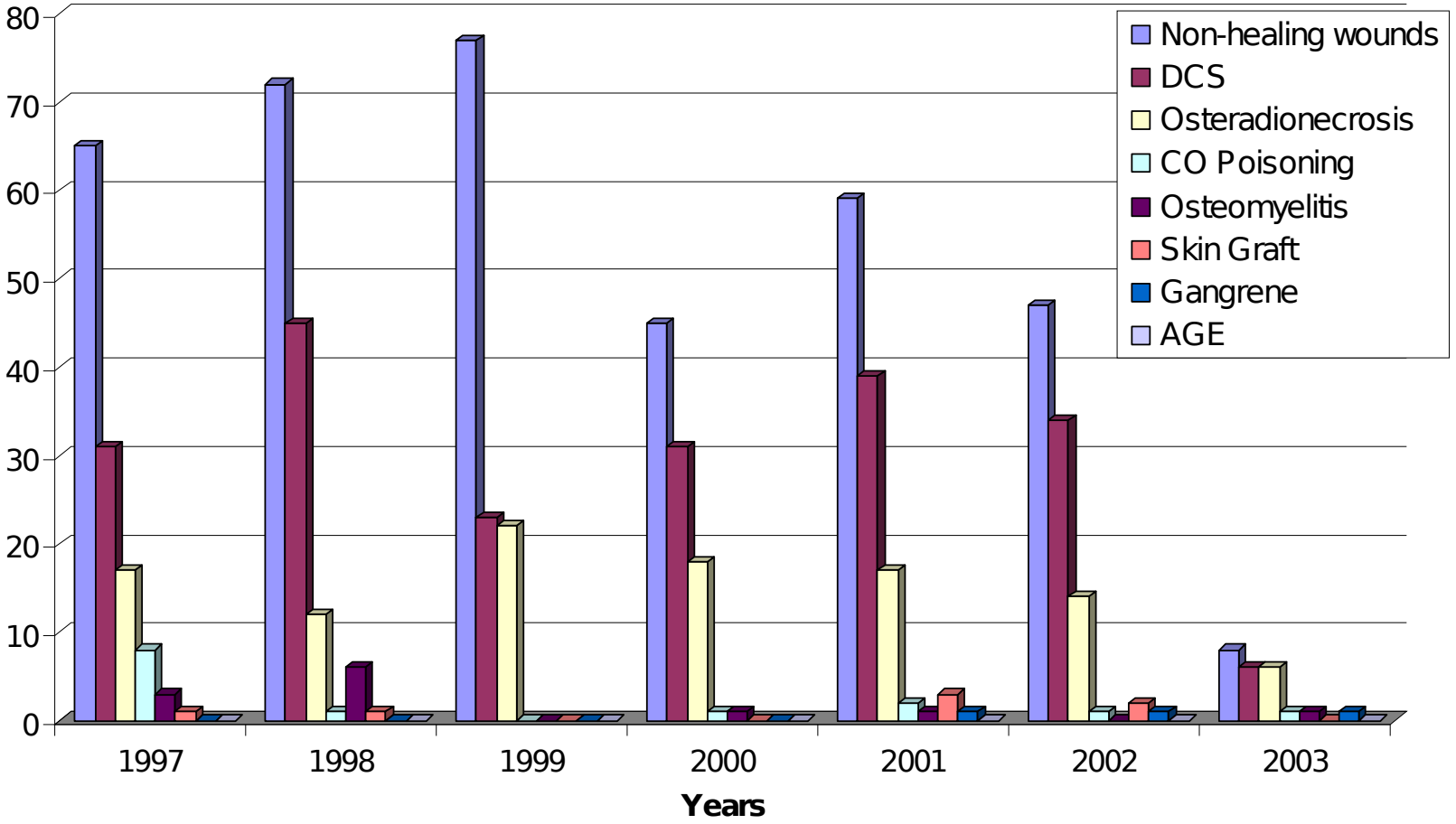
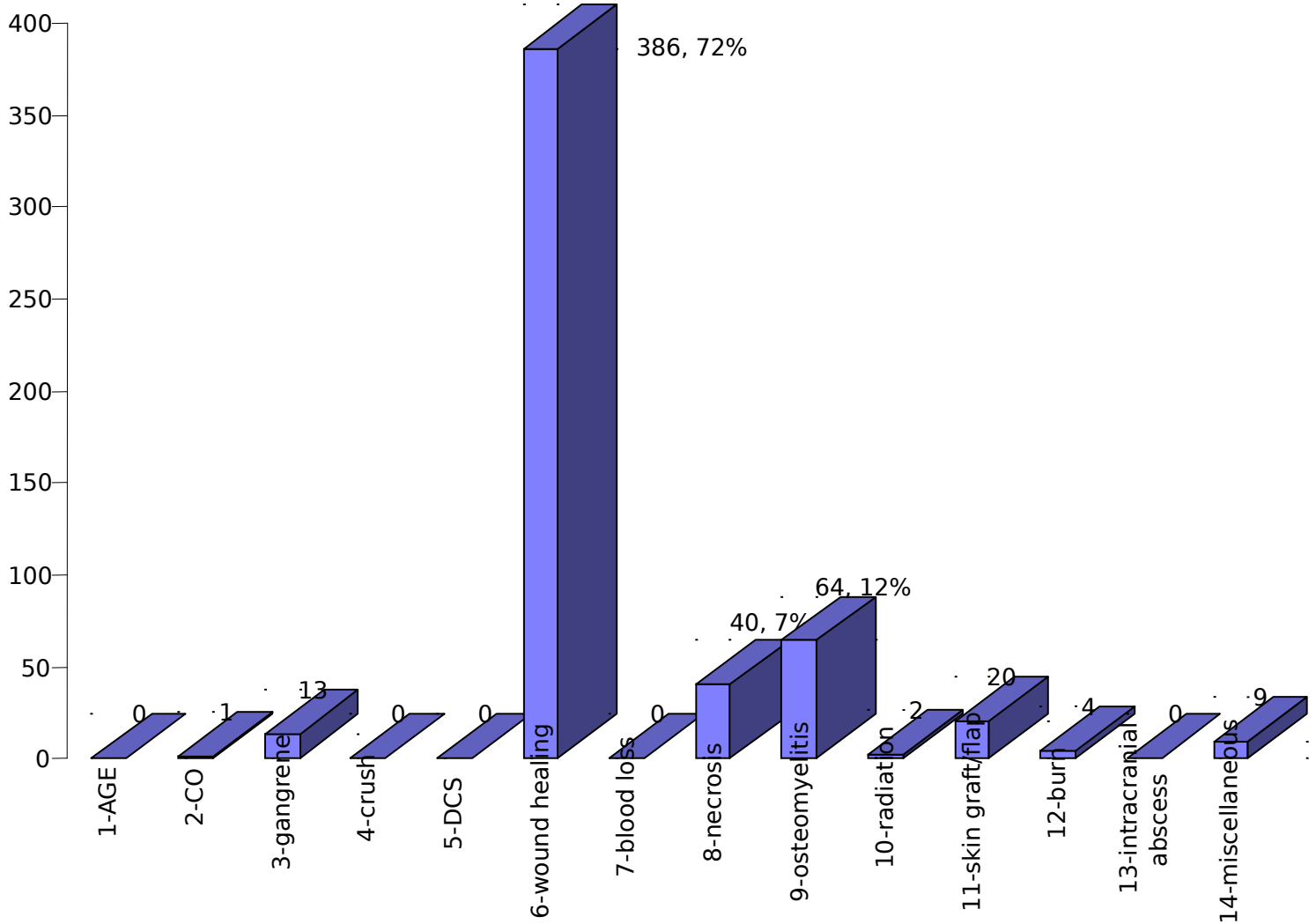

Yearwise distribution of cases managed with HBOT 1997- Mar 2003 (n=724)
Number of cases
160
140
120
100
80
60
40
20
0
125
137
122
96
122
99
23
1997
1998
1999
2000
2001
2002
2003

Results

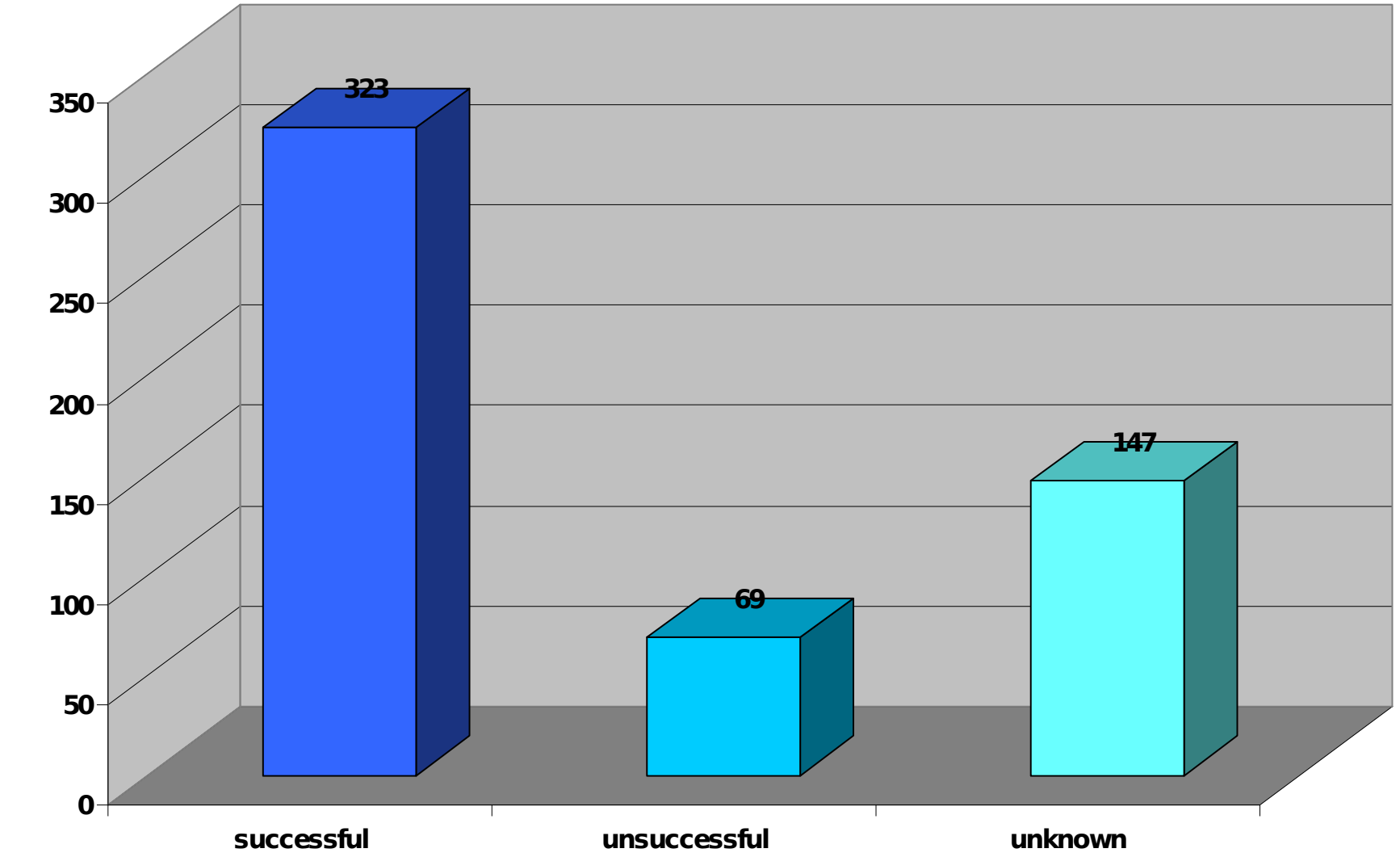
Workload distribution as per condition



UHMS Indication Scores of Patients Seen at Davis Hyperbaric laboratory Since 19



Outcome Diabetic



Wound Care Protocol

- **History**
  - Age/ Occupation
  - Cause/ Duration/ Underlying factors
  - Socioeconomic status
  - Co morbid conditions
  - Medications
  - Patient’s expectations of the outcome
- **Physical Evaluation**
  - Focused to the ailment
  - Attributing and/ or aggravating factors
  - Informed consent

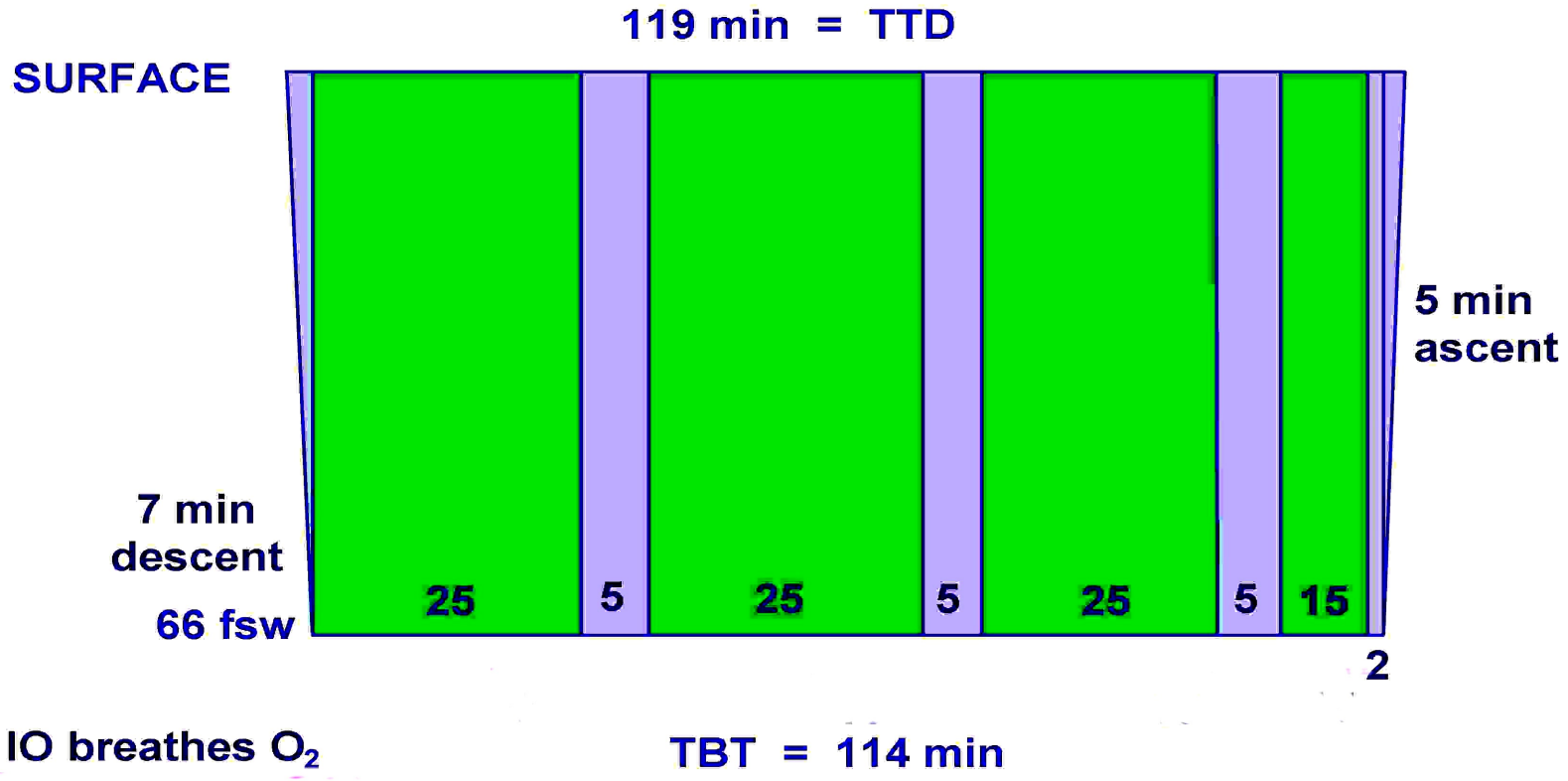
Wound Care Protocol

- **Assessment of the wound**
  - Size: Measured by tape/ traced. Depth is recorded.
    - Digital Photograph
  - Edges: margins and undermining
  - Wound bed: Necrotic slough, Fibrin exudates, odour, and granulation tissue
  - Surrounding tissue: color, moisture & suppleness
- **Record**
- **Debridement**
  - Surgical/ Mechanical/ Autolytic/ Enzymatic

Wound Care Protocol

- **Wound cleansing**
  - Get rid of the excess fibrin/ necrotic tissue and keep the wound moist
- **Topical dressings**
  - To achieve moist wound environment
  - Control excess exudates/ necrotic material
  - Maintain optimal temperature/ protect
  - Keep free from clinical infection
- **Advanced modalities**
  - Grafts/ Skin substitutes/ Physical modalities
- **Medications**- Titrate

Wound Care Dive Profile



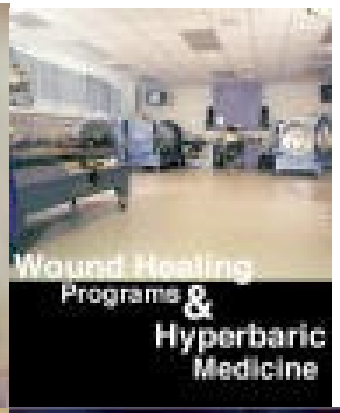
Salient features

- **HBOT in Non Healing Wounds**
  - Statistical evidence exists
- **Wound Care Protocol studied**
  - Wound dressings
  - Remediation of underlying problems such as hyperglycemia
  - Debridement of nonviable tissue
  - Restoration of adequate tissue perfusion
  - Limitation of pressure at the wound site
  - Control of infection

Salient features

- Wound aetiology
  - Team evaluation
  - Mid course review
  - System- vascular, neurological, musculoskeletal and dermatologic.
- Demonstrate periwound hypoxia
- Assess Risk and rule out contraindications
- Administer HBOT
- Reassess improvement & demonstrate improvement
- Oxygen- a drug

Questions!



Acknowledgements

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- Staff of Davis Hyperbaric Laboratory
- Patients at Davis Hyperbaric Laboratory